TRADITIONAL EXTERNAL TIMBER CLADDING IN MEDITERRANEAN CLIMATES.

Camila Burgos Leiva [1], Jaume Avellaneda Díaz-Grande[2], Vladimir Rodríguez Trujillo[3].

ABSTRACT: The study analyzes the traditional external timber cladding in the Mediterranean climate, in order to better break down their behavior through time of some of them.
An analysis of timber cladding used outdoors is made, considering 3 case studies of houses (from year 1900 onwards, as traditional architecture) taking into account the way this coating has responded and developed as time has passed; and performing typologies of wood cladding in Mediterranean climates.
It details the species of wood used, sections and details of their placement forms, finishes and protection that everyone possesses.
Finally a number of features and recommendations for the use of this noble material in this specific type of climate is obtained, allowing to make the best use of the material (wood) in housing construction, with specific data regarding what happens to each of the case studies.

KEYWORDS: Facades, timber cladding, wood, traditional architecture, mediterranean climate.

1 INTRODUCTION

This research is related to the doctoral thesis "wooden facades in Mediterranean Climate", being a part of the issue discussed in this document. The thesis presents issues related to testing of wood to exposure of weather for 2 years to ensure its durability and how different wood species degrade with different types of finishes and protections in different locations: 1. Sant Cugat, Spain, 2. Barcelona, Spain, 3. Lleida, Spain, 4. Santiago, Chile, 5. Concepción, Chile. Additionally, this research incentivizes the use of wood in the current construction, since it is a material that has all the features required today regarding "sustainability", and promotes the use of local woods. At the same time, it gives options for the use of wood in the rehabilitation of facades.

The study focuses exclusively on the Mediterranean climate which is present in countries that are primarily located in the vicinity of the Mediterranean Sea in Europe and Africa, Central and South America, California, southwestern Australia, South Africa (Cape Town) and Chile (central part.) Temperatures are mild in winter and warm in summer. The annual average temperature is between 14ºC and 16ºC, the temperature fluctuates between 13ºC and 18ºC. Winter is cool and the average temperature is between 5ºC and 10ºC, and the summer temperate varies between 23ºC and 24ºC. The variable rainfall fluctuates between 400 and 700 mm of rain in a year in dry areas, and between 700 and 1100 mm in the humid areas, with winds that generally do not exceed 20 km / h.

Fig 1 World Map of the distribution of the Mediterranean climate and location of the case studies. www.madrimasd.org

The traditional architecture on a Mediterranean weather is mainly based in stone, adobe and brick; however, wood has been used in some places – for example, can has been used in simple, light with average longevity housings in Cherchell, Argelia (coastal area and inland plains). It can be said that 47% of the housing is made of stone, an 8% is a combination (stone/soil – stone/brick),

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30% is brick and adobe, 10% not-kneaded ground and 5% stubble or straw [2].

Let us agree that the traditional architecture in Mediterranean climates generally uses local materials, and the use of wood is more frequent in floors and roofs. Wood is also used in the decorative parts of the façade such as balconies, window frames, doors and the protruding volumes of the facade itself. These local materials are extracted, produced and processed in the area. The use of these materials is usually due to their accessibility, avoiding the concern of transporting materials from further afield, considering that in the past it was more difficult and also very expensive, which is why builders of that time were forced to adapt to the materials they had at their disposal, regardless of the quality or the outcome that this had in the construction. Additionally, these materials were chosen for their adaptability to the mechanical and climate requirements of each building construction elements.

The construction techniques are ancient, accompanied by traces of cultural mixing, showing the marks and remnants of each era and the versatility of the rooms, which is why these techniques have not evolved, because everything was slower and this it is difficult for new materials and influences to intervene. This is the reason why the traditional architecture in Mediterranean climates has difficulties evolving technologically, accommodating to the limitations of available materials on a budget.

Wood has been used in many countries as facing facades. In general, the facade was finished with a painting that required regular maintenance, relying on a stand made completely of wood.

The outer coatings are often used only in the main facade or the one which is largely exposed to rain and wind, in the traditional architecture in the Mediterranean, 75% of the types in general use coating, from which the most frequently used – 45% - is the lime-mortar, 15% is gypsum-based mortar, a 15% is land-based mortar and the remaining 25% don't have coating. This part of the buildings and especially of the facades is very important because they reflect the skin covering the buildings, it is the visible face, which is why we focus in detail in some parts in this study, since it is possible to see how deteriorated and this part of the facade is, and how has it reacted to the degrading weathering [2].

Wood is a renewable natural resource, it offers significant environmental advantages favoring ecosystem support processes and providing enormous guarantees as a raw material with high mechanical and aesthetic potential for construction, always bearing in mind the controlled exploitation of forests (considering the concern about the years it takes to grow the various species).

In the 3 case studies clear examples of buildings enrolled in traditional architecture are shown, as well as describing the way the wood was used in the siding, the size of the pieces of siding, wood species used, the way it has degraded (which pathologies are shown) and the type of finish and protection that has been used.

2 TYPES OF TRADITIONAL WOODEN FACADE IN MEDITERRANEAN CLIMATE

In this particular kind of composed architecture, half-timbered walls can be mainly found, although presenting different images, playing with the volume and the walls (outgoing, incoming, design of windows, decorative overhangs, open or closed volumes, etc.) This framework allows to compose three-dimensional rigid set that integrates walls and floors, sometimes even the armor covers. The structural bays work well, since many of their horizontal pieces support and distribute the loads of the vertical girder.

The vertical girds exceed the 15 cm x 15 cm section, being oak or chestnut the species used. The strips (secondary parts) have a section that can go from 7,5 cm x 2,5 cm. to 14 cm x 2,5 cm, which is usually made of pine, cypress and eucalyptus.

A wide and varied range of different traditional facades can be seen in this material, from the most solid to the most organized, very meticulous and very detailed.

The traditional facade is mainly defined by the following elements:

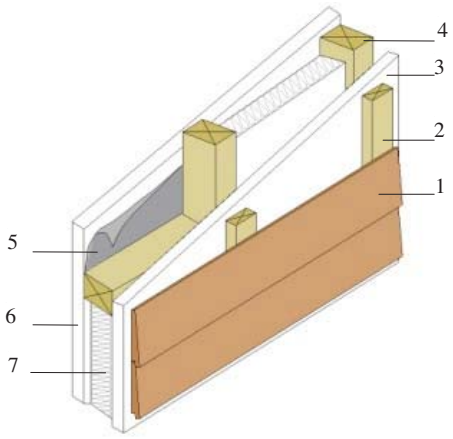

Fig. 2 (1) Siding, (2) wood slats, (3) Lining, (4) vertical girder, (5) wind and vapor barrier, (6) Lining, (7) Thermal insulation.

Every traditional facade has a ventilated air chamber, which avoids the condensation from reaching the interior of the house, allowing the air to circulate between the siding and the main pillars of the facade. Additionally, this air chamber avoids that the dimensional changes of wood, being the hygroscopicity an intrinsic quality of this material.

The construction system in most observed cases is almost always similar, which is a structure based on vertical girders. The differences are mainly in the species of wood used in the siding (oak, pine, larch, etc.) as well

as forms of placement (horizontal and vertical slats, tiles, etc).

In order for the facade to work properly, the crossbeams (battens) and strips that support the wooden paneling should be placed in a discontinuous manner to allow air to circulate better throughout the chamber. Out of the many buildings observed, the horizontal slats have a small inclination to better facilitate the rainwater drainage. Another possibility was to round the edges of the pieces, so as to allow rainwater to run in a better way, avoiding water to settle at the corners.

The exterior cladding of the traditional facades observed are mainly built with horizontal slats as a primary placement, intensifying the horizontality of the building. These coatings were primarily built with local wood species. The forms are varied but are always supported by a main structure of wood. Steel or copper nails fix them; although in some cases it has been observed that oxidation (through runoff) has generated spots on the facades.

3 WOOD SIDING

Wood and organic materials panelling are exposed to biotic attacks of insects and fungi, and are also exposed to the risk of decay due to the poor lace ventilation and waterproofing defects. This is the reason why its use was abandoned over time; however, nowadays it is possible to use wood, with the advent of new technologies and the myriad of products on the market created to overcome the negative aspects that mainly affect the use of timber.

Features of a good facade cladding are the following:
- Dimensional stability.
- Avoids condensation.
- Good thermal insulation.
- Water resistant to water and wind.
- Durability over time.
- Fire resistance.

The wooden facades can be classified into different types depending on their characteristics. The ones that exist in the traditional Mediterranean architecture are named and the most commonly used are detailed below:

3.1 Method of placement of the siding

Horizontal (channel, lapped, and tongue and groove), Vertical, Diagonal or Mixed (vertical and horizontal.)

Horizontal placement, the system consists of sticking to the horizontal boards to the vertical battens, which are fixed to the enclosure (distance 60 cm approximately). The fasteners can be done with galvanized nails or screws of a small diameter to avoid splitting the wood, and with a length of 70 to 80 mm. This typology can be found in most of the examples of traditional architecture.

3.1.1 Horizontal channel siding.

Placing one table on another covering the top edge creates this particular siding. Overlaps of the horizontal boards must be at least 30 mm. Water runoff is very good in this placement system, especially when the edge of the lower table ends in eaves. However the air is transferred more easily, which is why a windbreak was usually placed behind the ventilated chamber.
The most common sizes are 22 x 95 mm - 22 x 120 mm - 22 x 145 mm.

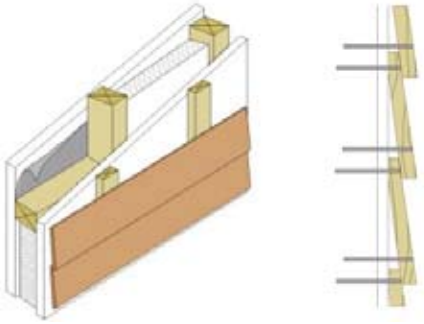

Fig. 3 Isometric and horizontal channel siding.

3.1.2 Lapped Horizontal Sheathing

The union between them is along their length, through the layout of its edges, one piece being partially mounted on another part. The variety of profiles is large, which is why it is important to make sure they have good water drainage. The overlap should be over 7 mm, but it also depends on the width of the table. The most common dimension is 22 x 120 mm.

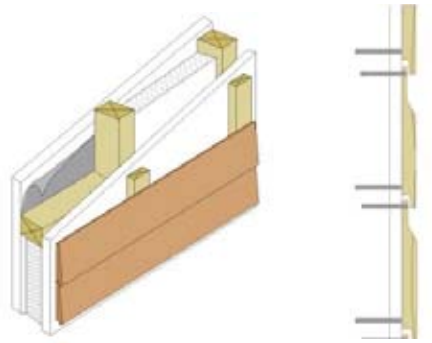

Fig. 4 Isometric and horizontal lapped siding.

3.1.3 Horizontal Tongue and Groove Decking

These tables have in their upper edge a tongue and a groove on the bottom. The tongue and groove joint had to be of at least 10 mm, although it will also depend on with of the table. Common dimensions are 22 x 95 mm, and 22 x 120 mm.
Usually there is a tongue and groove clearance to allow hydrothermal movements of the lamas.

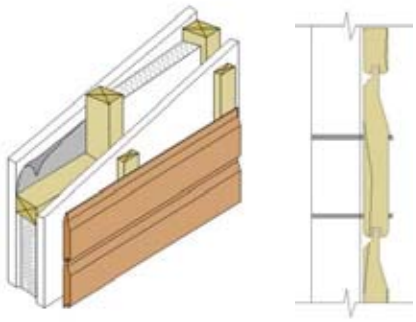

Fig. 5 Isometric and horizontal groove and joint siding.

3.2 Treatment of joints: Open or Closed.

Closed: This type of joint is fairly waterproof and generates a clear link between the parts, e.g. by overlapping or dovetailing. Such treatment often does not present reinforcement to the sealing.

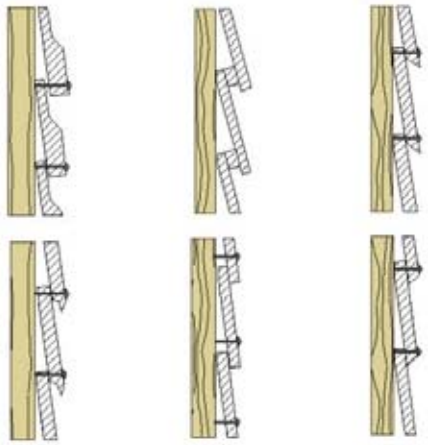

Fig. 6 Examples of the closed boards with nails.

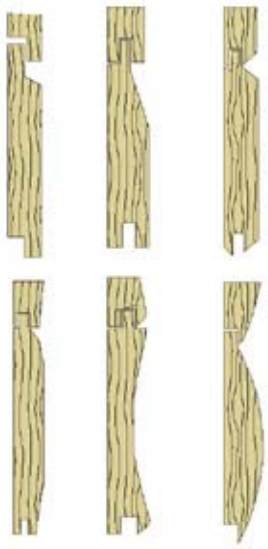

Fig. 7 Examples of closed boards by assemble.

In overlapping siding, horizontal overlap is usually of at least 30 mm, since this has a good runoff, especially when the lower edge has a glob.
In the tongue and groove decking, for a good drainage of water, there usually is a certain clearance and a depth necessary to allow variation of the timber. The tongue and groove should increase proportionally with the width of the table, the wider the width of the sheathing the higher the risk of deformation, cracking and warping. Tables with an additional groove on its outer face have been found, which allow the possible cracks at this location to occur in a controlled manner.

3.3 Appearance

Surface finish such as paints, varnishes and oils.
The paint finish is the most widely used in the protection of wooden slats being the predominant in this type of architecture.

The paints are pigments and resins in different solvents covering the wood forming an opaque and / or colored layer. They are more effective than varnishes. Conventional paints form a continuous film. We have oil paintings - resinous and oil.

3.4 Protection

Most of the traditional architecture does not use protection because in those days more technological protection did not exist.

We see that in most cases of Mediterranean climate traditional architecture, the horizontal siding is used engaged with different forms of placement, creating a closed joint, which has more tightness therefore not allowing the passage of water. That is why all cases of study have this specific type.

As for the sections, it can be said that the coatings of a larger section have a worse outcome due to the hygroscopic deformation of timber. The blades can not be very narrow, since it generates a higher amount of joints, where there can be potential points of water leakage of moisture transfer liner. The fixing is also an important issue because if they are poorly made, they can generate filtration points and water penetration.

That is why a more deep analysis of three case studies will be made.

4 CASE STUDIES

Three case studies from different countries and continents with this kind of weather are now presented.

1. Sant Cugat, Spain.
2. Istambul, Turkey.
3. Temuco, Chile.

(A) (B) (C)

Fig. 8 Case studies (A) Sant Cugat, Spain, (B)Istambul, Turkey, (C)Temuco, Chile.

In both the cases of Turkey and Chile the traditional architecture is present, however the case of Sant Cugat imported technology from Canada is used. In each case wood was predominantly used as a cladding material, maintaining throughout the years in a relatively good condition. In Spain, the use of wood is more unusual unlike the cases of Turkey and Chile.

The 3 houses are all made of wood siding, not from the same species though because each used timber available in the surroundings. They are also built in the same period of time between 1900-1920. They all have the same number of years without any substantial changes made in the architecture of each.

The coating consists of horizontal wooden slats, with tight joints, paint surface finish (the pores of the wood close with this product) and do not have any form of protection.

The study is mainly focused on the behavior of the open timber over time.

Case A (Sant Cugat - Spain).
Single family home built in 1902; its geometry is square without any outgoing or incoming surfaces on its facade, it has a concrete floor and a cover with hip-roof to 4 skylights in the rear facade overlooking the garden. The siding is of Oregon pine (coniferous) imported from Canada with a horizontal tongue and groove panel section of 3 "x 1" (7,5 x 2,5 cm) with its structure made entirely of wood, and fixed with nails. No kind of protection treatment was made to the wood of this house, and it only has a superficial finish of paint (now green), which has helped keep the wood throughout the years. The house shows problems mainly in the south facade (which is constantly exposed to wind, rain and sun), where problems of decay and warping of wood has generated, both in the liner and in the window frames.

Case B (Istanbul - Turkey).
Traditional Turkish family house with a “sofa” on the inside, built approximately in 1910, enrolled in a group of semi-detached houses with side firewalls. It has a ground floor made of brick (masonry), a gable roof without skylights, the façade has a predominance of straight lines and a bowindow spanning 2 floor, the window frames are made of local wood eaves and the sill and eaves, also made of wood, are neoclassical. Its cladding is made of oak slats (leafy) without any protection, brought from their own forests, with a 5" x 1" section (12,5 x 2,5 cm) with horizontal overlapping slats, fixed by nails, complete with a wooden structure made of local species (oak and pine). The surface finish on the basis is white paint, maintaining the wood, considering as well that the south facade is hidden between the firewalls, which are why the deterioration of the exposed facades is lower. Further deterioration by moisture can be found in the joints of the wood paneling (overlaps), the windows and the bowindow.

Case C (Temuco - Chile).
Single family home built in 1920, located in a corner, for which it has the presence of the sun, rain and humidity all year round. 2 floors with a socket on the ground floor made of brick (masonry), covered with gambrel roof, with skylights to illuminate the interior of the house and a hexagonal tower, which gives hierarchy to the access of the house. The structure was built with the wood truss system, such as Balloon frame. The species of wood used is Pellín, and is called locally oak heartwood, being a native wood used extensively in this city not only for coating but also for the structure and floor beams. The section of siding is 3" x 1" (7,5 x 2,5 cm), channel horizontal shed. Similarly to case A (Sant Cugat), the house presents further deterioration in the north facade (change of hemisphere) due to rain, sun and humidity. We see that the coating has gaps in the joints, deformation by moisture and rot in the sill by the accumulation of rainwater in the winter time.

By having 3 locations with a similar climate but in so distant geographic locations from each other we can see how the facade behaved over time, taking into account each of the factors affecting this situation.

Given that there are many factors that can severely affect the deterioration of wood and finish, not just the typical factors of heat and excessive cold or moisture and rain.

We already have a clear description of each of the houses; this allows us to make a general parameter of the characteristics and qualities of each.

5 DISCUSSION

The 3 case studies present different problems in the way they behave in the open through time, we see that Case B (Turkey) is the most deteriorated, followed by Case C (Chile) and finally the Case A (Spain) is the best preserved house, with only some peculiarities of low importance, as it has been well maintained over time.

It is also important to say that there are several factors that can affect their evolution (decay) over time, and also the specific environments in which they develop or external agents that could deteriorate.

This is why a summary detailing the characteristics of each of the case studies:

		CASE A	CASE B	CASE C
WOOD SPECIES	CANADIAN PINE OREGON	X		
	OAK		X	X
SECTION	3" X 1"	X		X
	5" X 1"		X	
UNPROTECTION		X	X	X
SETTING	NAILS	X	X	X
FORM OF PLACEMENT	DOVETAILING	X		
	UNDERHAND		X	
	SHED			X
FINISH	PAINTING	X	X	X
	VARNISH			
PATHOLOGY	HUMIDITY	X	X	X
	SHELLING			X

Fig. 9 Summary of the characteristics of the case studies.

Shrinkage of wood: Timber movements in the north and south facades according to the continent (northern in South America and South in Europe), where it presents more damage from moisture and movement of wood due to greater presence of moisture and the rainfall that comes directly. This climate is characterized by very distinct seasons, being these facades (north and south respectively) the ones that suffer most in summer (high temperatures and high relative humidity) and winter (low temperature, rainfall and the presence of high relative humidity). It shows the damage of the joints of the boards, decay and openings (cracks) in these areas and the openings of windows and doors. It is also important to note that depending on the size of these wooden slats they will move, crack or change according to the way they were designed. In Cases A and C we have the same dimension of the slats (3" x 1"), which helps their dimensional changes not to be as important as opposed to the slats of the case B (5" x 1") that if we movements which have occurred in the sheathing and also by their morphology is easier for the wood to split. Cutting wood in tangential section lamas helps to control the dimensional changes.

Fig. 10 Case B, where the higher number of deformations is presented.

Finishing Behavior: Due to problems in maintaining the facades, great deterioration is shown especially in cases B and C. Since the finish has cracked and allowing to see the bare wood in many parts of the facade, due to the fact that the wood was not treated, this house has deteriorated even faster. This is mainly seen in the frames of doors and windows in both cases.

Fig. 11 Case B Fails in the finishing of the window, cracking.

Fig. 12 Case C Fails in the finishing of the window, cracking.

The *discontinuity* in the strips help to generate a camera, ventilating the facade and cladding, this is very important in building with wood, because if not for this camera significant deformations in the front would be seen, and it would not let the air circulate within it, generating significant condensations and movements in the siding.

Horizontal slats Boards: This is one of the most controversial issues in a façade entirely made of wood, as it is by this point that its water tightness is tested. The 3 cases have a closed board, since their horizontal sidings are tongue and groove (case A), overlap (Case B) and channel (Case C). Only Case A has the corner of the blade that faces the outside rounded, helping the runoff of rainwater, and since it is dovetailed it complicates the water to penetrate the interior. In Case B where the blade has a greater dimension and a drawn on the outer face at the same time, a splitting of the piece in a specific place is generated, the conflictive corner for the sealing of the façade is covered through a beveled; on the other hand, on Case C the solution is the simplest of all because in each of the blades an inclination of the blades is generated for the water to run easier, having in the corner a short beveled as a leak (drip).

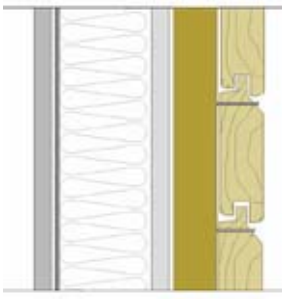

Fig. 13 Case A, detail of the exterior siding.

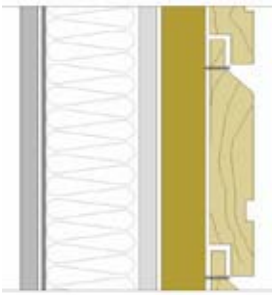

Fig. 14 Case B, detail of the exterior siding.

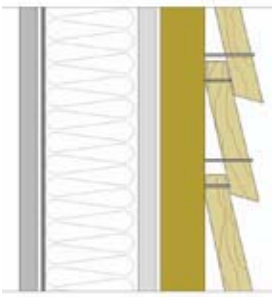

Fig.15 Case C, detail of the exterior siding.

Volumetry of the facade: It is an important part in the composition of the facades, but when the house presents more outgoing volumes as in the cases B and C (most impaired), a greater number of meeting points is generated, accumulating moisture in the meeting places, especially in the facades, being the effects worse because of the rain and the sun in different seasons, as well as the presence of shadow which makes it degrade more easily as fungi agents appear deteriorating wood faster, especially when the house is not well maintained. As seen in the picture of case C which is the most affected one.

Fig. 16 Northern facade in case C, Temuco, Chile.

Major deterioration in each of the case studies:

Fig.17 Case A, collapse of the wooden slats on the window.

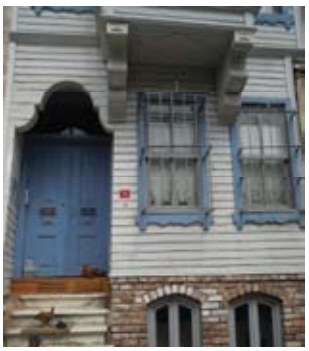

Fig. 18 Case B, sinking of the wooden slats on the access door and window scaling.

Fig. 19 Case C, paint peeling on the facade and presence of fungi in the meeting of the facade with the bowindows.

Protection of the heads of the pieces: This is another weak point of the use of timber in construction, because if they left in sight, this is where there is more capillarity, allowing the passage of water and moisture. In Cases A and C all the corners are left in sight, but they are protected by a structural pillar unlike the Case B which is a semi-detached house, for which no heads have to be protected in its facade since the perimeter walls are embedded.

Fig. 20 Case A, it has structural columns that line the front edges of the slats.

Fig. 21 Case C, it has structural columns that line the front edges of the slats.

The *fixings* of the 3 cases are made by *nails*, and were well kept and performed by people trained for this, since none of the cases show cracks or stains on the siding generated by rust from the nails.

It is also important to say that there are several factors that can affect their evolution (decay) over time, as well as the specific environments in which they develop or external agents that could cause decay.

The action of ultraviolet rays where the hole in the ozone layer is higher (as it is in Temuco, Chile) accelerates the process of deterioration. There are also cities with higher environmental pollution, having in their environment acids generated by saline environments (near the sea), which also accelerates the process of wood exposed outdoors deterioration.

6 CONCLUSIONS

Due to the architectural heritage, it can be concluded that wooden facades generally follow a similar pattern as the use of air space for venting wood, nails for fixing or various board joints that help absorb the expansion and contraction of this material, making it clear that they have broad similarities between them. This shows that despite the passing of the years similar methodologies and systems are still in use, with the existence nowadays of a wider range of products, allowing more options when designing, without neglecting other aspects to be considered such as climate, orientation, and the different species used.

Regarding the case studies we can see that the behavior of the durability of wood siding depends on a high percentage on maintenance, as we see in the case studies of the Sant Cugat's house (case A), kept in excellent condition nowadays, due to the fact that the surface paint finish has been kept in good conditions, so that the surface does not crack leaving the wood exposed allowing water and moisture to enter. The three cases were built between 1900-1920, which shows that this material remains in time for over 100 years.

In relation to wood finishes it can be stated that the painting is the most used finishing and the one that works best, keeping it properly, as it leaves the pores of the wood closed and does not allow the passage of water, unless it cracks allowing the water to penetrate the coating.

Wood is an excellent material for use in facade, provided that relevant maintenance is made through time, because wood is a natural material and it changes its shape according to the amount of moisture it absorbs or releases, but it remains strongly recommended to be used as an exterior siding. Additionally, one of the factors that affect wood is solar radiation (UV) promoting the deterioration of both wood and its finish, clearly showing on the aesthetics of color, because it changes as time passes (when wood has no protection or finishing, it turns grey).

As to the types of wood facades, the air ventilation chamber is used in most cases. It is recommended that these cameras have at least 5 cm, in order to work correctly; this ensures somehow the ventilation of slats of wood to prevent cracking generated by the movements of these parts and to better control condensation.

The method of attachment of the siding is mostly horizontal slats (channel, lapped, tongue and groove), always taking into account the space that should be left at the junctions of each of the blades so they can absorb large hydrothermal movements without difficulties. The closed joint generated in the slats allows us to create a better seal coating not allowing the wind, water and/or humidity to penetrate inside.

In the case studies we see that the 3"x 1" dimensions work properly, since it has more options for mobility and also has a number of junctions that prevents water to penetrate easily. Unlike Case B in which the blade is larger (5" x 1") it can be seen more problems with the siding showing more failures in the board warps. In order to reduce the movement of the slats, a continuous groove around the inner face is recommended, which should be approximately 1/3 of the edge of the table.

The fixing is important, therefore the use of copper nails (properly made) is recommended, since they do not generate staining reaction with the wood tannin.

The solutions are varied, basically it can be seen that when the necessary maintenances of the paint surface finish are made, the product works better, therefore having the siding in good conditions for a long time. If the design is made carefully regarding the construction details such as rounding the edges of the wood slats, thus allowing rainwater to run better and avoiding it to settle in the corners, generating the fungi formation and the leakage of water into the interior of the house; the heads of the pieces are a weakness if they are visible, because water penetrates easily through capillary, therefore is advisable to protect them with metal lids or wood, in the cases studied they are protected by structural wooden columns in each of the corners (cases A and C).

Modern construction has infringed this way of building, since different kinds of wood siding are used nowadays, from conifers to tropical timber and even boards with different forms of protection (oils, salts, heat-treated), different kinds of finishing (wood stains, varnishes), different kinds of support (from wood to traditional media) and different processes (from assemblies to precast panels), despite the new technologies at our disposal, it can be said in this study that the correct use of wood allows the material to endure for over 100 years.

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